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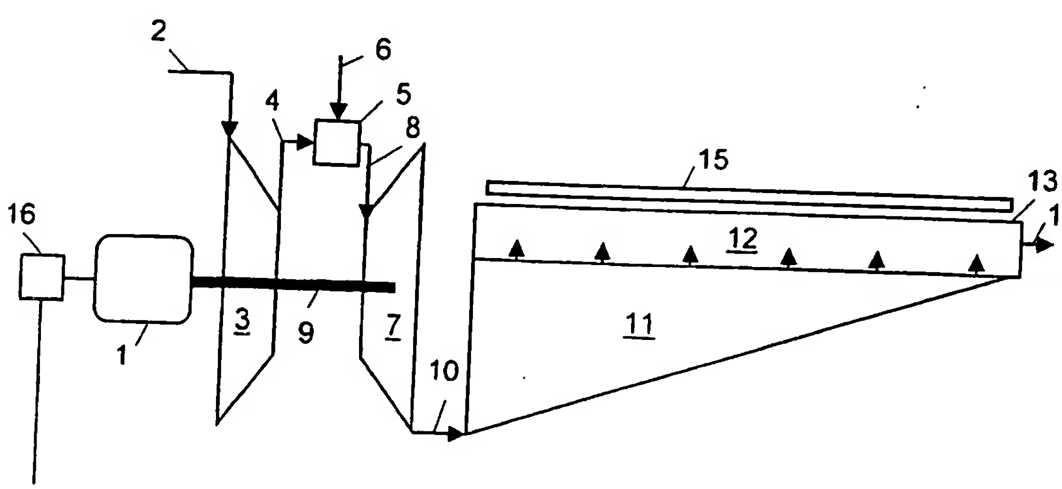

(57) Abstract: This invention discloses a method and a device for drying material. According to the invention electricity and heat is produced, whereby the heat is produced by burning fuel (6), which forms flue gases (8), which are guided to a flue gases utilising, electricity producing device (1, 7), after which device (1, 7) the flue gases (10) are at least partly guided to driable material or the flue gases are guided at least partly to a heat transferring surface (12)...

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ENERGY ECONOMICAL COMPACT DRYING SYSTEM

This invention relates to a method for drying material and a drying module for realising the method.

The apparatus used in the process drying are usually convection dryers, conduction dryers, radiation dryers or their combinations.

In the convection dryers hot gas, often air, is blown to the surface of the material to be dried. It is aim to break the aqueous vapour layer on the surface of the material and thus to increase the evaporation of water from the material.

In the conduction dryers the surface to be dried is brought into the surface that conducts heat and that functions as a dryer. Often rotating, cylindrical drum or rollers are used as drying chambers or drying surfaces.

In paper and textile industry drying cylinders are commonly used for process drying. The drying cylinders are typically hollow cylindrical bodies, which are closed by end plates or flanges. The lead-ins are typically in the end plates or flanges. The drying cylinders are usually made of cast iron or of steel.

In papermaking the paper web is typically dried with the aid of a hot roller surface. High-pressure steam or hot oil is lead into the hollow roller or into the drying cylinder, which steam or oil warms the surface of the cylinder. The paper web is conducted to the surface of the rotating roller or the cylinder, whereby the paper web warms and water evaporates from the paper web. The steam led into the drying cylinder condensates to water on the walls of the drying cylinder, the condensate is gathered and is removed from the cylinder.

The paper web is, however, wet in the beginning of the drying and it may adhere to the surface of the drum or of the drying cylinder causing tear or stretching of the edges of the paper web. If the paper web is in contact with a surface having too hot surface, when the dry solids content is below 70 %, the uppermost layer of the paper is closed and the water left inside is boiling out causing parcelling and

cracking. The drying must take place slow enough to avoid this. Usually the surface temperature of the drying cylinder is 160 – 180 °C. When the speed of the paper machine rises, the drum or the cylinder drying itself causes the longer drying parts.

The most usual way to warm the drying cylinder is to use steam. The steam is generated concentratedly in the paper mill and the steam is delivered via a pipe system to the steam consumers. For generating steam fossil fuel, waste wood or black lye is usually used as a fuel. In the process there are caused losses in the steam boiler, in the distribution network and in the drying cylinder.

The drying cylinder is under a high stress when acting as a pressure vessel, when it is heated by steam. The steam must be high-pressured in order to achieve the required heat power. Thereby the material thickness of the cylinder must be sufficient, which leads to a high wall thickness and increases the weight of the cylinder. On the other hand the heat transfer from the inner surface of the drying cylinder to the driable material on its outer surface diminishes when the thickness of the cylinder shell increases. In practice the steam pressure restricts the surface temperature usable in the cylinder, and the surface temperature of the cylinder can not be chosen freely as required by the needs of the process e.g. in the paper making.

In radiation dryers the heat transfers as an electromagnetic radiation between two surfaces. E.g. in the paper industry electrical or gaseous radiation dryer are used, wherein as a radiant surface there is a lamp equipped with a back reflector. The efficiency of the electrical infrared dryer is low, typically 20-30%, because of inter alia the fact that the wavelength area of the radiation falls to an unfavourable region for the water molecules. The efficiency of the gaseous infrared dryers is typically a little higher.

US Patent documents 6,073,857 and 6,161,768 disclose a micro turbine system, which is used conventionally to heat gas or air with the aid of heat exchangers.

The dryers of the prior art technique have as a drawback their minor efficiency, the great weight and their constricted transformation of energy to heat.

The object of this invention is to remove the drawbacks of the prior art technique and to generate a new solution to dry material, whereby the drying of the material is integrated to the energy system and to the process of a factory. This is realised by the steps of the characterising part of the claim 1 and by the arrangements of the characterising part of the claim 10. The characterising features of some advantageous embodiments of the invention are presented in the dependent claims.

The method and apparatus is especially advantageous when extra capacity is needed to the drying, because the heat and the electricity are produced decentralised in the direct proximity of the process. There is no transmission losses, no transfer piping of steam is needed, no blowers are required and the possible extra electric consumption can be covered by the method or by the apparatus itself.

According to one advantageous embodiment of the invention the flue gases coming out of the device utilising the flue gases are led to a space that is at least partially cylindrical, with which cylinder the material is driable.

One advantageous embodiment of the invention is based to the utilisation of micro turbine technique. Hereby the drying module consists of a micro turbine, a compressor, a combustion chamber, a generator and a drying portion. As the parts of the drying module are positioned near to each other, the developed drying module is very compact. After the turbine the flue gases are led to the drying portion, where their temperature is raised by an afterburner if required.

When using a cylindrical dryer the flue gases are led after the turbine into a cylindrical dryer via the fittings formed in the end or in the ends of the dryers. If required the flue gases can also be led after the turbine into the afterburner, where their temperature is raised. After the afterburner the flue gases are led into the cylindrical dryer.

The compressor arranged on the same axis as the turbine does not require the whole rotating power of the axis produced by the turbine and the electric power generated the generator can be led to a device needing electric power, to the energy system of the mill or even to the mains of the power plant. The efficiency produced by the arrangement according to the invention, i.e. the ratio of the utilised electric and heat power to the required fuel power, is good.

The greatest part of the power produced by the drying module is got as a heat power. The produced electric power is typically 25-35% of the used fuel power in a turbine compressor generator system, when it is realised with the micro turbine technique. As heat generated portion is in the category of 40-55% depending on the required drying temperature. E.g. the heat power of the drying module could be 160 kW without the afterburner and 200 kW with the afterburner and in addition to this the electric power could be 100 kW. The total efficiency of the drying module is thereby 25...85% or even higher depending on the temperature level of the last heat consumer. The heat energy of the flue gas exiting from the drying module can further be recovered in a gas/air heat exchanger or in gas/water heat exchanger. E.g. an air heating system can function as a heat recovery device. Hereby the total efficiency increases. The lowest efficiency describes a situation where the drying module is driven only for the electricity production, e.g. when reserve power is needed. The total efficiency of the advantageous embodiment according to the invention is thus remarkably higher than the efficiency of the conventional dryers. The given numbers are only trend setting and there is no hindrance to construct a drying module having a higher or lower power.

Typically the power range of the drying module realised by the micro turbine technique is 50...500 kW electric power. The energy production units used in the process industry have usually 5...30 MW of electric power. E.g. the drying part of a modern, paper machine with breadth of 10 m has typically drying capacity of 8 –24 MW heat power. The system constructed of drying module according to invention produces respectively drying heat power 9 – 27 MW and additionally 1,7 – 6,1 MW electric power when using the same amount of fuel. The electric capacity of the

drying module has thus a very suitable power range for the electric power consumption of a paper mill, which makes the investment of a central power plant unnecessary. According to an advantageous embodiment the micro turbine operates with a high rotating speed and rotates a high-speed generator, whose output voltage is first rectified and then inverted by a frequency converter to alternating current for the mains. The system provides either dc or ac current or both of them. The modern controlled electric drives are more frequently ac drives, where the mains current is first converted to dc and then converted to ac suitable for the control situation. By dc supply one conversion stage can be eliminated in the ac drive, which simplifies the control remarkably. The situation is likewise regarding the dc drive.

Conventional fuels, e.g. natural gas can be used as a fuel in the drying module. This is profitable in the situation, where the drying module or the drying modules are locating in surroundings, where there are also other devices or machines consuming fuel, e.g. the own power plant of the paper mill. The use of the natural gas is especially advantageous for certain embodiments of the invention, because the burning of the natural gas does not cause a harmful smut concentration in a flue gas. This is significant when the flue gas is wanted to drive directly to the driable surface. The drying modules can utilise also less conventional fuels like biogases or hot gases of the industrial processes.

Additional interruptions in a process cause remarkable costs in the process industry when the production stalls. The components of the drying module have typically long maintenance interval, 6000...8000 h and the serviceable components can be located favourably. When the machinery and drying part has been separated sequential, the turbine and the compressor can be serviced despite the material flow through the drying part. The drying module can be furnished with an afterburner so that while the machinery part itself is under service the drying cylinder may dry with reduced power.

The heat power transferring to the driable material can be controlled with the aid of the afterburner. Thereby additional air and if required additional fuel are arranged to

the afterburning. Typically the flue gases exiting from the micro turbine have temperature of 250-300 °C, and their temperature can be raised e.g. to 500 °C by afterburning. On the other hand the temperature of the flue gases can lowered if required by leading all or part of the flue gas through an heat exchanger before drying, on the other side of the heat exchanger flowing a colder material flow. E.g. when drying chemical pulp the temperature must be under 300 °C that no yellowing or cracking will appear. On the coater of the paper machine the coating material stands higher blowing temperatures, 500 – 600 °C, whereby the rising of the flue gas' temperature by the afterburning will come in question. Likewise the blowing air on the temperature level of 500 – 600 °C can be used in the soft tissue machines.

The heat transfer surface of the drying module can be formed according to each application. When drying the paper web the heat transfer surface could be e.g. elongated and could shape around the cylinder or the drum. In the drying of the peat the heat transfer surface could be cylindrical. The heat transfer can be made more effective by forming the heat transfer surface ribbed.

When the flue gas is fed into the drying cylinder to warm it, the drying cylinder need no more be a pressure vessel as is the case when steam is used as a heat source, whereupon the cylinder can be made of thinner material. The weight of the drying cylinder decreases in this case and the installation will become easier. When the thickness of the casing diminishes, the heat transfer gets also better from the inner surface of the drying cylinder to the driable material on the outer surface of the cylinder. The surface temperature of the drying cylinder is no more dependent on the steam pressure and on the constructional requirements set by the steam pressure, whereupon the surface temperature can be adjusted to a desired level within the limits set by the production material of the drying cylinder.

The space requirement of the apparatus is not remarkably greater than the one of the conventional dryer. The components needed in the drying module are arranged in a compact connection with each other.

The drying module is well suitable to be used as a process dryer e.g. in paper industry, in textile industry, in timber industry, in food industry, in pharmaceutical industry, in machine and electrotechnical industry and in treating different bulks.

In the paper industry the compact drying module according to the invention can be realised e.g. in a following way. The drying module consists of a micro turbine, a compressor, a combustion chamber and a generator and a drying cylinder. The drying cylinder is pillowed to rotate around its longitudinal axis, while the machinery part, i.e. the micro turbine, the compressor, the combustion chamber and the generator and the possible afterburner, are fixedly installed in place. The drying cylinder is rotated by a separate motor or e.g. by a fabric belt tightly strained on the outer surface of the cylinder and positioned under or on the paper web. The ends of the drying cylinder are thermally isolated to reduce the heat loss and to protect the parts installed on the ends. The paper web runs on the outer surface of the drying cylinder on the length of 180 °. The temperature of the flue gases is 250 – 350 °C after the turbine. When using the afterburner after the turbine and before the drying cylinder the temperature of the flue gases can be risen to 350 –450 °C. At least part of flue gases from the machinery part will be led to the drying cylinder through the fitting arranged to the end of the cylinder. In the drying cylinder there are guiding means, by which the flue gas is guided to the inner surface of the drying cylinder. Part of the inner surface of the drying cylinder is formed ribbed to make more effective the heat transfer from the flue gas to the inner surface. The cooled flue gas is removed from the cylinder through the fitting arranged to the other end of the drying cylinder. The guiding means of the flue gas can also be turned partly or totally to a by-pass position, if the surface temperature of the drying cylinder is wanted to decrease. The by-pass channel and the guiding means are positioned in such a way in the drying cylinder that they are not rotating with the drying cylinder but only the casing or drum of the drying cylinder rotates. With the aid of the by-pass arrangement of the flue gases the turbine and the electricity production need not be interrupted though the need of the drying heat decreases or fully ceases. The electric power generated in the generator of the drying module is used as driving power for the motors of the blowers needed for air-circulation or for the other motors

in the paper machine line. Micro-turbine-generator technique enables a decentrilised electric and heat power production in the close neighbourhood of the drive unit and enables to integrate the whole apparatus to the process. The arrangement remarkably improves the energy economics of the factory and simplifies the electrification of the factory and the control system of the process.

One embodiment of the invention in paper production is the one used in the hot calendering process. The paper web is calendered to get a smooth and even surface for the paper. The calender consists of two or several opposed drums, between which the paper web is pressed. It is advantageous for the paper quality if one of the drums is hot. Most commonly the drum for the hot calendering is heated by using oil. The required surface temperature of the drum is 150 – 350 °C. In the drying module in accordance with the invention the temperature of the flue gases is 250 – 350 °C after the turbine and the required part of the flue gases can be guided into the calendering drum through the fitting arranged to the end of the drum. In the drum there are guiding means, by which the flue gases are guided to the inner surface of the drum. The cooled flue gas is removed through the fitting in the other end of the drum or if the fittings are locating at the same end of the drum the flue gas is circulated with the aid of guiding means. The guiding means of the flue gas can also be turned partly of fully to a by-pass position, if the surface temperature of the drum is wanted to decrease. The by-pass channel and the guiding means are positioned in the drum so that they are not rotating with the drum but only the casing of the drum rotates. With the aid of the by-pass system of the flue gases the turbine and the electricity production need not be interrupted, though the need of the heat decreases or fully ceases. The electric power produced in the generator of the drying module is used as driving power of the motors in the paper machine line. By the arrangement the drawbacks of the oil system are avoided, like possible oil damage in connection of piping leakage.

The cylindrical drying part can also be utilised in drying of the particle-like materials. Then the drying part of the drying module consists of the drying drum that rotates. The driable particles, like e.g. wood chips, is fed into the drying drum from the one

end of the drum with flue gas coming from the gas turbine, and the dried wood chips and the cooled flue gases are removed from the other end of the drying drum. The construction of the drying drum depends on the driable material. Normally different guiding plates are installed in the drying drums, by which plates the material flow is aimed to divide to smaller parts to achieve a more constant drying result. The outer casing of the drying drum can also be perforated, whereby the moistness vaporised from the driable material is allowed to go out with the flue gas during the drying.

In the drying module the heat transfer from the flue gas to the inner surface of the drying cylinder can also be realised with the aid of surfaces with good heat radiation. These kind of well radiating surfaces are produced as elements made of e.g. ceramics. Then the flue gases are guided to flow through the channel constructed on the longitudinal axis of the cylinder, the walls of the channel being the surfaces with good heat radiation. The channel forms then an infrared radiator. To intensify the heat transfer form the flue gas to the radiating surfaces the essentially cylindrical channel can be equipped with different flow guides or ribs or the channel itself can be constructed e.g. as a spiral. To strengthen the heat transfer the inner surface of the drying drum can be covered by material, which absorbs or transmits well radiation.

The distance of the channel walls acting as infrared radiator from inner surface of the drying cylinder is chosen on the basis of purpose of use of the drying module and the characters of the radiating surfaces. Inside the channel there can be installed different fillings, by which the flow cross-section of the flue gases can be decreased in the channel. The type of the radiating surface can be e.g. centralising, whereby the radiation can be focused more exactly, or even, whereby the near-by target can be heated evenly, or the radiating surface can radiate broadly, whereby the radiation focuses farther on a large area. The flue gases cool when flowing in the channel, whereby the transferred heating power decreases. In order to get, however, an even surface temperature to the drying cylinder, different amount of radiating surface is positioned in the different parts of the flow channel. The

radiating surfaces need neither have the same type, but the most suitable element can be chosen to different longitudinal parts of the channel.

The channel acting as the infrared radiator can also be realised with a heat exchanger, inside of which there flows the flue gas and the outer surface of which is cased or e.g. coated with material radiating well heat.

The invention will be described in detail below with the aid of examples by referring to the attached drawings, the figures of that show the drying module according the invention.

Figure 1. Drying module.

Figure 2. Drying module with afterburner.

Figure 3. Drying module in a convection drying arrangement.

Figure 4. Drying module arranged to heat exchanger system.

Figure 5. Cylindrical drying module.

Figure 6. Cylindrical drying module arranged to heat exchanger system.

Figure 7. Cylindrical drying module with injector and with recuperator.

In the figure 1 there is shown a high speed generator 1, air supply 2, a compressor 3, compressed air 4, a combustion chamber 5, fuel 6, a micro turbine 7, flue gases 8, an axis 9, flue gases for drying 10, a distributor of flue gases 11, flue gas flow to the heated surface 12, heat transfer surface 13, flue gases exiting the drying module 14, the material to be dried 15 and a frequency converter 16. The corresponding numbering has been used in the other figures where applicable.

The compressor 3 sucks the fresh air 2 and pushes the compressed air 4 to the combustion chamber 5, where it mixes with the fuel 6 forming an air-fuel mixture. The air-fuel mixture burns in the combustion chamber 5, the flue gases 8 generated as a result of fast burning erupt with high speed via the blades of the turbine 7, whereby the kinetic energy of the flue gases rotates the turbine 7, which is positioned on the same axis 9 as the compressor 3 and the generator 9. The

rotating motion is converted to electricity by the generator 1. The hot flue gases 10 are led from the turbine to the distributor 11, which distributes the gas flow 12 evenly to the heat transfer surface 13, on the other side of which the driable material 15 is moving or is in place. The cooled flue gas 14 is removed from the drying module. The output current produced by the generator 1 is converted by the frequency converter 16 to mains current, which drives electric devices, like e.g. electric motors, or which supplies the electric network of the plant.

In the figure 2 there is shown compressed air flow 21 to an afterburner, the afterburner 22, a distributor 23 of flue gases, flue gas flow 24 to the surface to be heated, a heat transfer surface 25, flue gases exiting from the drying module 26, material to be dried 27, a frequency converter 28 and supply of the additional fuel 29.

The compressor 3 sucks the fresh air 2 and pushes the air 4 into the combustion chamber 5 and the air 21 to the afterburner 22. The flue gases 10 are led from the turbine to the afterburner 22, where their temperature is increased by burning the particles that were not burnt in the combustion chamber with aid of the compressed air flow 21 or if required of the additional fuel 29. The flue gases are led to the distributor 23, which distributes the gas flow 24 evenly to the heat transfer surface 25, on the other side of which the material 27 to be dried moves or is in place. The cooled flue gas 26 is removed from the drying module. The output voltage of the generator 1 is converted by the frequency converter 28 to mains voltage, which drives electric devices, like e.g. electric motors, or which supplies the electric network of the plant.

In the figure 3 there is shown a circulation air channel 31, circulating air 32, a gas guiding device 33, a drying cylinder 34, a paper web 35, flue gas-air mixture 36, a blower 37, flue gas air mixture exiting from the circulation 38, a heat recovery system 39 and a frequency converter 40.

The flue gases 10 are led from the turbine 7 to the circulation air channel 31, where they are mixed with the circulating air 32 removed from the paper web. The flue

gases are led to the gas-guiding device 33, wherefrom they are blown towards the surface of the paper web 35 lying on the drying cylinder 34. In the figure there is shown only one gas guiding device 33, but if required there can be several, even tens of gas guiding devices, e.g. one after another in the direction of the paper web's movement. The humid flue gas-air mixture 36 is sucked from the paper web, and one part 38 of it is guided out through the heat recovery system 39 and the other part 32 of it is recirculated to the drying by the blower 37. The output voltage of the generator 1 is converted by the frequency converter 40 to the mains voltage, which supplies other electric devices, like e.g. the blower 37.

In the figure 4 there is shown compressed air flow 41 to an afterburner, the afterburner 42, a distributor 43 of the flue gases, flue gas flow 44 to the surface to be heated, a heat transmission surface 45, flue gases exiting from the drying module 46, a gas/air heat exchanger 47, ba gas/water heat exchanger 48, a gas/water heat exchanger 49, a gas/air heat exchanger 50, input flue gas 51, output flue gas 52, input flue gas 53, output flue gas 54, input flue gas 55, output flue gas 56, input flue gas 57, output flue gas 58, flue gas 59, input air 60, output air 61, input water 62, output water 63, input water 64, output water 65, input air 66, output air 67, exiting flue gas 68, a paper web 69, a blower 70, a frequency converter 71, and supply of additional fuel 72.

The compressor 3 sucks fresh air 2 and pushes the air 4 to the combustion chamber 5 and the air 41 to the afterburner 42. The flue gases 10 are led from the turbine to the afterburner 42, where their temperature is increased by burning the components of the flue gas that were not burnt in the combustion chamber and if required by feeding additional fuel 72. The exhaust gases are led to the distributor 43, which distributes the gas flow 44 evenly to the heat transmission surface 45, on the other side of which the driable paper web 69 is moving. The cooled flue gas 46 is removed from the drying module. The blower 70 is used to transfer the flue gas. The output voltage of the generator 1 is converted by the frequency converter 71 to the mains voltage, which supplies other electrical devices, like e.g. the blower 70. One part 51 of the flue gas 46 is guided to the gas/air heat exchanger 47, where it

warms the air 60, 61 for the compensation air of the inverted funnel of the paper machine, and one part of the flue gas is guided to the by-pass channel 59. The ratio of the by-pass gas 59 and the gas 51 guided to the heat exchanger 47 depends on the power needed in the heat exchanger. For each heat exchanger 47 – 50 there has been arranged the by-pass 59. The flue gas 52 coming from the heat exchanger 47 is mixed with the gas in the by-pass channel 59 and one part 53 of the flue gas is guided to the gas/water heat exchanger 48, where it heats the process water 62 of the paper machine, one part of the flue gas is guided to the by-pass channel 59. The flue gas 54 coming from the heat exchanger 48 is mixed with the gas in the by-pass channel 59 and one part 55 of the flue gas is guided to the gas/water heat exchanger 49, where it heats glycol water 64, 65 and one part of the flue gas is guided to the by-pass channel 59. The flue gas 56 coming from the heat exchanger 49 is mixed with the gas in the by-pass channel 59 and one part 57 of the flue gas is guided to the gas/air heat exchanger 50 utilising low heat energy, where it heats the open air 64, 65 and one part of the flue gas is guided to the by-pass channel 59. The flue gas 68 is guided from the by-pass channel 59 to the open air. The gas/air heat exchanger 50 is a heat exchanger of the air heating, whereby the temperature of the flue gas may be dropped below 20 °C. The heat exchanger system can of course consist of only part of the shown heat exchangers or more than the shown four heat exchangers depending on the needs of the heat recovery.

The solutions described in the examples above can naturally be combined according to the needs of the application. E.g. the solution described in the figure 1 can be used for drying of the paper web by the radiation dryer and concurrently the solution described in the figure 3 can be used as the convection dryer e.g. so that the radiation and the convection dryers are positioned side by side or on the two sides of the paper web. Then the radiation and the convection dryer can form one or more drying module.

In the figure 5 there is shown a drying cylinder with a cylindrical drying part. There has been described the high speed generator 1, the input air 2, the compressor 3, the compressed air 4, the combustion chamber 5, the fuel 6, the micro turbine 7, the

flue gases 8, the axis 9, the flue gases for drying 10, a frequency converter 111. In addition there has been represented by the reference numbers guiding means of the flue gases 112, guiding means of the flue gases 113, flue gases 114 coming from the drying module, a drying cylinder 115, the inner room 116 of the drying cylinder, the inner surface 116' of the drying cylinder, the driable material 117 and a by-pass channel 118. The corresponding numbering has been used in the figures 6 and 7.

The compressor 3 sucks the fresh air 2 and pushes the compressed air 4 to the combustion chamber 5, where it mixes with the fuel 6 forming an air-fuel mixture. The air-fuel mixture burns in the combustion chamber 5, the flue gases 8 generated as a result of fast burning erupt with high speed via the blades of the turbine 7, whereby the kinetic energy of the flue gases rotates the turbine 7, which is positioned on the same axis 9 as the compressor 3 and the generator 1. The rotating motion is converted to electricity by the generator 1. The hot flue gases 10 are led from the turbine to the guiding means 112 of the flue gas, which distributes the gas flow evenly to the inner surface 116' of the cylinder in the inner room 116 of the drying cylinder 115, on the other side of which the driable paper web 117 moves, or which fully or partly guide the flue gases into the by-pass channel 118. The flue gas cooled in the cylinder 115 is gathered by the guiding means 113 and the flue gas 114 is removed from the drying module. The output current produced by the generator 1 is converted by the frequency converter 111 to the mains current, which drives electric devices, like e.g. electric motors, or which supplies the electric network of the plant.

In the figure 6 there is shown guiding parts 119 of the flue gas, a blower 120, a by-pass channel 121 of the drying cylinder, an afterburner 122, compressed air 123 to the afterburner, flue gas flow 130 to the heat recovery, a gas/air heat exchanger 141, a gas/water heat exchanger 142, a gas/water heat exchanger 143, a gas/air heat exchanger 144, input flue gas 131, output flue gas 132, input flue gas 133, output flue gas 134, input flue gas 135, output flue gas 136, input flue gas 137, output flue gas 138, input air 151, output air 152, input water 153, output water 154,

input water 155, output water 156, input air 157, output air 158, exiting flue gas 139 and a by-pass channel 140 of the heat recovery.

For the flue gas 10 exiting from the turbine 7 it is reserved the by-pass channel 121 of the drying cylinder for the situation, when the drying cylinder 115 is not possible to use for some reason and, however, there is use for the generated electricity. The by-pass can also be used when the heating power needed by the heat recovery part is greater than it can be produced by the flue gas 114 exiting from the drying cylinder 115 and because of the reasons of the adjustablity one does not want to use the by-pass channel 118 inside the drying cylinder 115. The flue gas 10 exiting from the turbine 7, or part of it, is heated by the afterburner 122 if needed in order to increase its temperature before the flue gas is led into the drying cylinder 115. Additional air 123 is brought to the afterburner 122 from the compressor 3. The hot flue gases coming from the turbine 7 or from the afterburner 122 or from both of them are led into the drying cylinder 115 to the guiding means 112 of the flue gases, which distribute the gas flow evenly to the inner surface 116' of the cylinder. Inside the drying cylinder 115 there are guiding parts 119 of the flue gas, which guide the flue gas flow inside the drying cylinder. The blower 120 is used to transfer the flue gas 114 cooled in the drying cylinder 115 to the heat recovery 141, 142, 143, 144. The output voltage of the generator 1 is converted by the frequency converter 11 to the mains voltage, which supplies other electric devices, like e.g. the blower 120. One part 131 of the flue gas 130 is guided to the gas/air heat exchanger 141, where it heats air 151, 152 for the compensation air of the inverted funnel of the paper machine and one part of the flue gas is guided to the by-pass channel 140. The ratio of the gas guided to the by-pass channel140 of the heat recovery and the gas 131 guided to the heat exchanger 141 depends on the power needed in the heat exchanger. For each heat exchanger 141 - 144 there has been arranged possibility to use the by-pass channel 140. The flue gas 132 coming from the heat exchanger 141 is mixed with the gas in the by-pass channel 140 and one part 133 of the flue gas is guided to the gas/water heat exchanger 142, where it heats the process water 153, 154 of the paper machine, and one part of the flue gas is guided to the by-pass channel 140. The flue gas 134 coming from the heat exchanger 142 is

mixed with the gas in the by-pass channel 140 and one part 135 of the flue gas is guided to the gas/water heat exchanger 143, where it heats glycol water 155, 156 and one part of the flue gas is guided to the by-pass channel 140. The flue gas 136 coming from the heat exchanger 143 is mixed with the gas in the by-pass channel 140 and one part 137 of the flue gas is guided to the gas/air heat exchanger 144 utilising low heat energy, where it heats the open air 157, 158 and one part of the flue gas is guided to the by-pass channel 140. The flue gas 139 is guided from the by-pass channel 140 to the open air. The gas/air heat exchanger 144 is a heat exchanger of the air heating, whereby the temperature of the flue gas may be dropped below 20 °C. The heat exchanger system can of course consist of only part of the shown heat exchangers or more than the shown four heat exchangers depending on the needs of the heat recovery.

In the figure 7 there are shown hot flue gases 160, a well radiating surface 161, guiding parts 162 of the flue gas, flue gases 163 exiting from the drying module, additional air 170, an injector 171, flue gases 172 exiting from the injector, a recuperator 173, heated air 174.

The flue gas 10 exiting from the turbine 7 is guided to the injector 171. The flue gas 10 is mixed with the additional air 170 in the injector and the flue gas amount 172 usable to the drying increases. The temperature of the flue gas 172 exiting from the injector is lower than the temperature of the flue gas 10 exiting from the turbine 7. The flue gases 172 exiting from the injector are guided to the recuperator 173. The recuperator 173 increases the efficiency of the turbine by heating the air 4 led from the compressor 3. The heated air 174 is guided to the combustion chamber 5. The recuperator 173 also lowers the temperature of the flue gases 172 to the desired level before the flue gases are led to the drying cylinder 115. The flue gases 160 are guided from the recuperator 173 into the channel lined with well heat radiating elements 161 inside the drying cylinder 115. The guiding pieces 162 of the flue gas have been installed in the channel guiding the flow of the flue gas. The guiding pieces 162 can also act as heat transfer surfaces. The flue gases flow in the

channel heating the well heat radiating elements 161. The cooled flue gases 163 are removed from the other end of the drying cylinder 115.

In the examples described above e.g. the afterburner, the injector or the recuperator has been illustrated only in one example. However, it is clear that these components can be combined as required according to the needs of the application. E.g. when willing to lower the temperature of the flue gas before the drying cylinder the flue gases can be guided after the turbine to the recuperator, where they cool heating the compressed air, and the flue gases are guided from the recuperator to the drying cylinder. The recuperator can also be replaced by a heat exchanger, whereby the desired drop of the temperature of the flue gas is achieved before the drying cylinder and the heat transferred from the flue gases can be utilised e.g. in the heating of the compensation air of the paper machine's inverted funnel.

The drying module according to the invention can be used e.g. for drying of peat. Then it is advantageous to guide the flue gases from the turbine to direct contact with the peat in the drying cylinder, where they are mixed. The peat particles are separated from the flue gas after the drying e.g. in a cyclone, after which the flue gas either partly or fully is recirculated to the drying part, is guided to the heat exchanger system or to open air through the chimney. Alternatively, the flue gases exiting from the turbine can be guided to the heat-transferring surface, on the other side of which the peat is brought.

With the same principle as in the peat drying the drying module can be utilised when drying granural material, like resin or plastic granules, or powdery materials. When producing e.g. plastic articles by blow moulding it is necessary to dry the plastic granules used as raw material before the actual blowing to the mould. Then the flue gas exiting from the turbine is guided by the blower to the lower part of the drying chamber, wherefrom it rises by the gravity or by a possible thrust air flow through the driable material towards the upper part of the chamber removing the moisture from the material. After this the flue gas partly or fully is recirculated to the drying chamber, is guided to the heat exchanger system or is guided to the open air

through the chimney. The electric power from the drying module is utilised e.g. in the blowers required by the process.

The drying module according to the invention is applicable as a drying furnace. E.g. when manufacturing bricks the moisture of the raw bricks is typically 12 – 16 % of weight. In order to prevent the bursting of the brick because of the evaporation during the burning phase, the brick is dried to the moisture of about 1 %. In this application the drying part of the drying module consists of the drying furnace, whereto the flue gases of the turbine are led. The flue gases are mixed with air before they are blown into the drying furnace to achieve the respective required temperature of the gas. Generally temperatures of 180 – 290 °C are used. After this the flue gas partly or fully is recirculated into the drying furnace, is guided to the heat exchanger system or is guided to open air through the chimneys. The electric power produced from the drying module is utilised e.g. in the blowers required by the process or in the other targets of usage.

There are plenty of heating and drying furnaces in the machine and electrical industry, where the drying module of the invention can be applied. These kinds of applications are e.g. the cleaning, drying and painting of the parts, enamelling, drying of the transformer-winding etc.

It is clear for the man skilled in the art that the different embodiments of the invention are not limited to the examples described above, but they can vary in the scope of the following claims.

CLAIMS

1. A method for drying material, **characterised** in that according to the method electricity and heat are produced, whereby the heat is produced by burning fuel (6), which creates flue gases (8), which are led to a device (1,7), which utilises the flue gases and generates electricity, after which device the flue gases (10) are guided at least partly to the driable material (35) or the flue gases are guided to a heat transferring surface (13,25,45), on the other side of which there is the driable material (15,27,69,117).

2. A method according to the claim 1, **characterised** in that the flue gases (10) are guided at least partly into a cylindrical space (116), with the aid of which cylinder the material (117) is dried.

3. A method according to the claim 1 or 2, **characterised** in that the heat power produced by the method is greater than the electric power.

4. A method according to any of the claims 1 - 3, **characterised** in that the flue gas utilising device (7) is a micro-turbine.

5. A method according to any of the claims 1 - 4, **characterised** in that electricity is produced from the axis (9) rotated by the micro-turbine (7) with the aid of a generator (1).

6. A method according to any of the claims 1 - 5, **characterised** in that at least part of the flue gas (10) exiting from the flue gas utilising device (7) is heated in order to raise the temperature of the flue gases (10).

7. A method according to any of the claims 1 - 6, **characterised** in that at least part of the flue gas (114) is guided after the drying module to at least one heat exchanger (141,142,143,144).

8. A method according to any of the claims 1 - 7, **characterised** in that the cylinder (115) is rotated around its longitudinal axis.

9. A method according to any of the claims 1 - 8, **characterised** in that at least part of the flue gas (114) is transferred with the aid of a blower (120).

10. A drying module, **characterised** in that electricity and heat is produced by the arrangement, and wherein the heat is producible in a combustion chamber (5) by burning fuel (6), and whereby generating flue gases (8) are guidable to a device (1,7) utilising the fuel gases and producing electricity, after which device (7) the flue gases (10) are at least partly guidable to the driable material (35) or the flue gases are at least partly guidable to a heat transferring surface (13, 25, 45), on the other side of which surface the driable material (15, 27, 69) lies.

11. A drying module according to the claim 10, **characterised** in that the flue gases (10) are guidable to an at least partly cylindrical room (116), by which cylinder the material (117) is driable.

12. A drying module according to the claim 10 or 11, **characterised** in that the heat power produced by the drying module is higher than the electric power.

13. A drying module according to any of the claims 10 - 12, **characterised** in that the fuel gases utilising device (7) is a micro-turbine.

14. A drying module according to any of the claims 10 - 13, **characterised** in that electricity is produced from an axis (9) rotated by the micro-turbine (7) by a generator (1).

15. A drying module according to any of the claims 10 - 14, **characterised** in that the generator (1) is a high-speed generator, the output voltage of which is converted by a frequency converter (11).

16. A drying module according to any of the claims 10 - 15, **characterised** in that at least part of the flue gas (10) is heatable after the flue gases (10) exited from the flue gases utilising device (7) for increasing the temperature of the flue gases (10).

17. A drying module according to any of the claims 10 - 16, **characterised** in that the inner surface (116') of the cylindrical space is ribbed to improve the heat transfer.

18. A drying module according to any of the claims 10 - 17, **characterised** in that at least part of the flue gas (114) is guidable to at least one heat exchanger (141, 142, 143, 144).

19. A drying module according to any of the claims 10 - 18, **characterised** in that at least part of the flue gas is transferable by a blower (120).

20. A drying module according to any of the claims 10 - 19, **characterised** in that the flue gases utilising, electricity producing device (1, 7), and the cylindrical space (116) are connected to each other to form one unity.

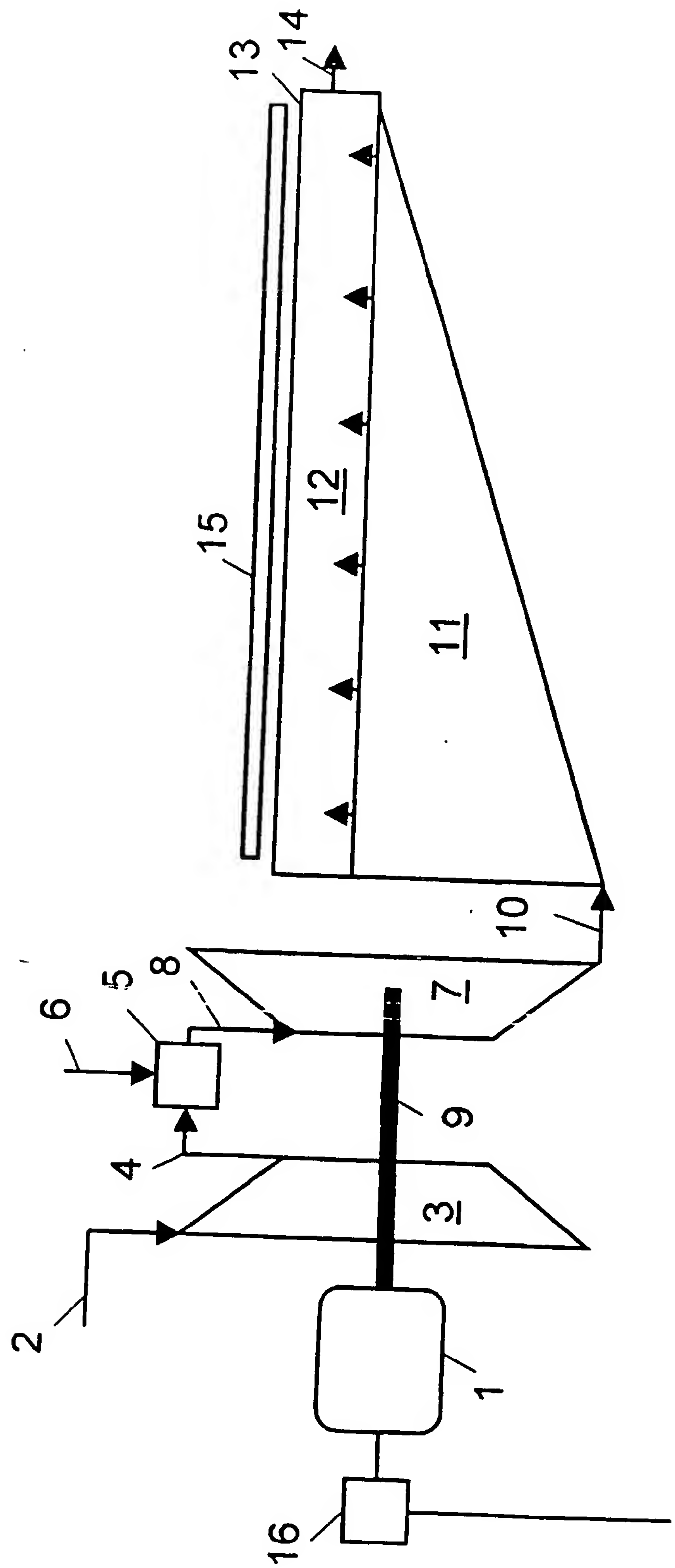

Fig. 1

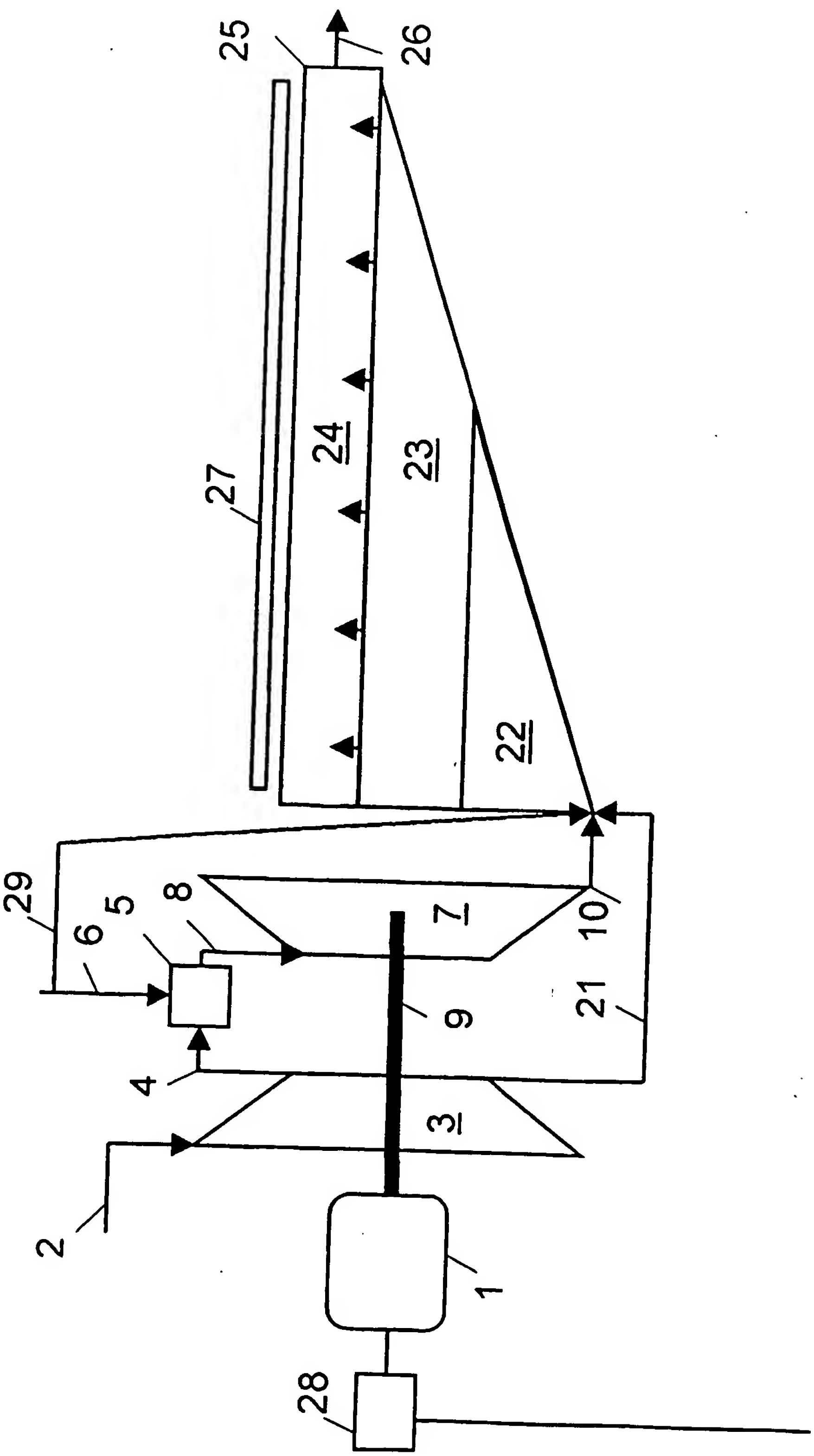

Fig. 2

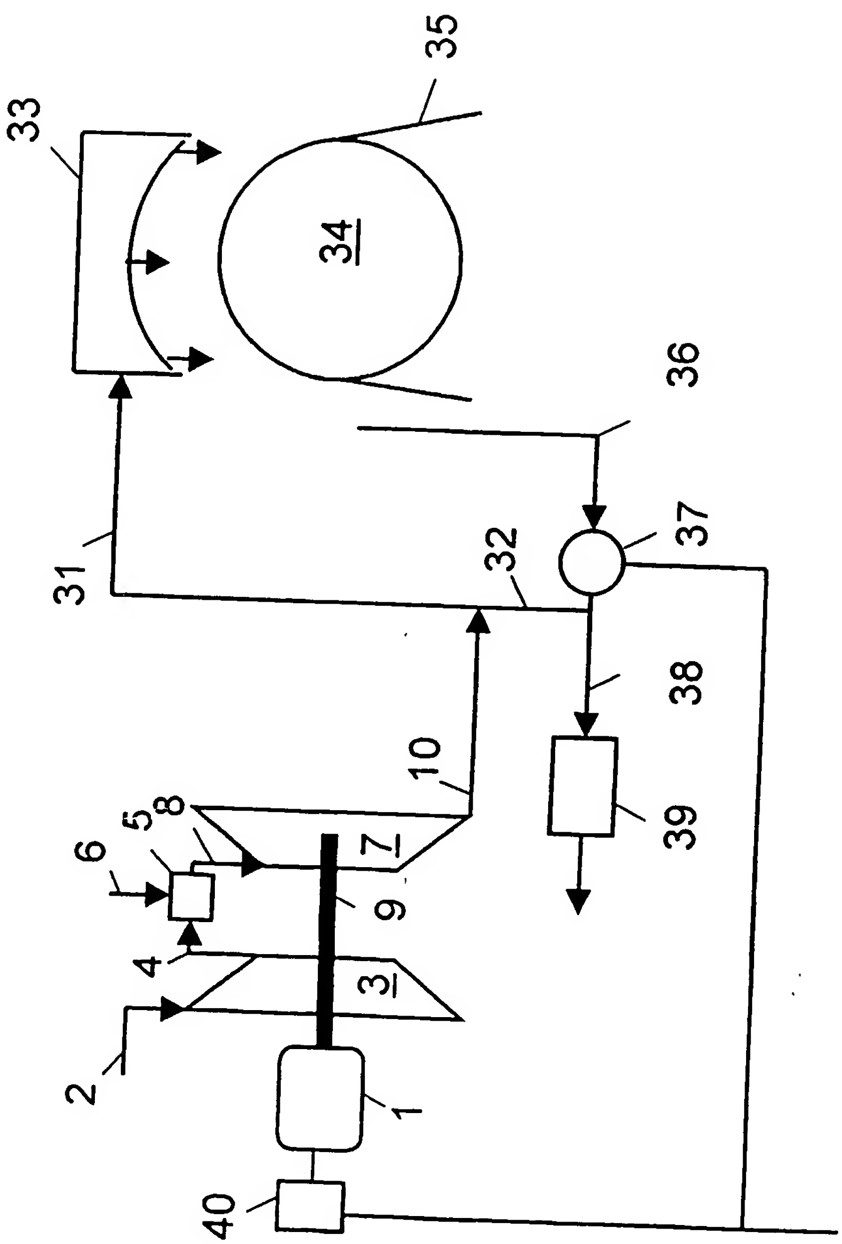

Fig. 3

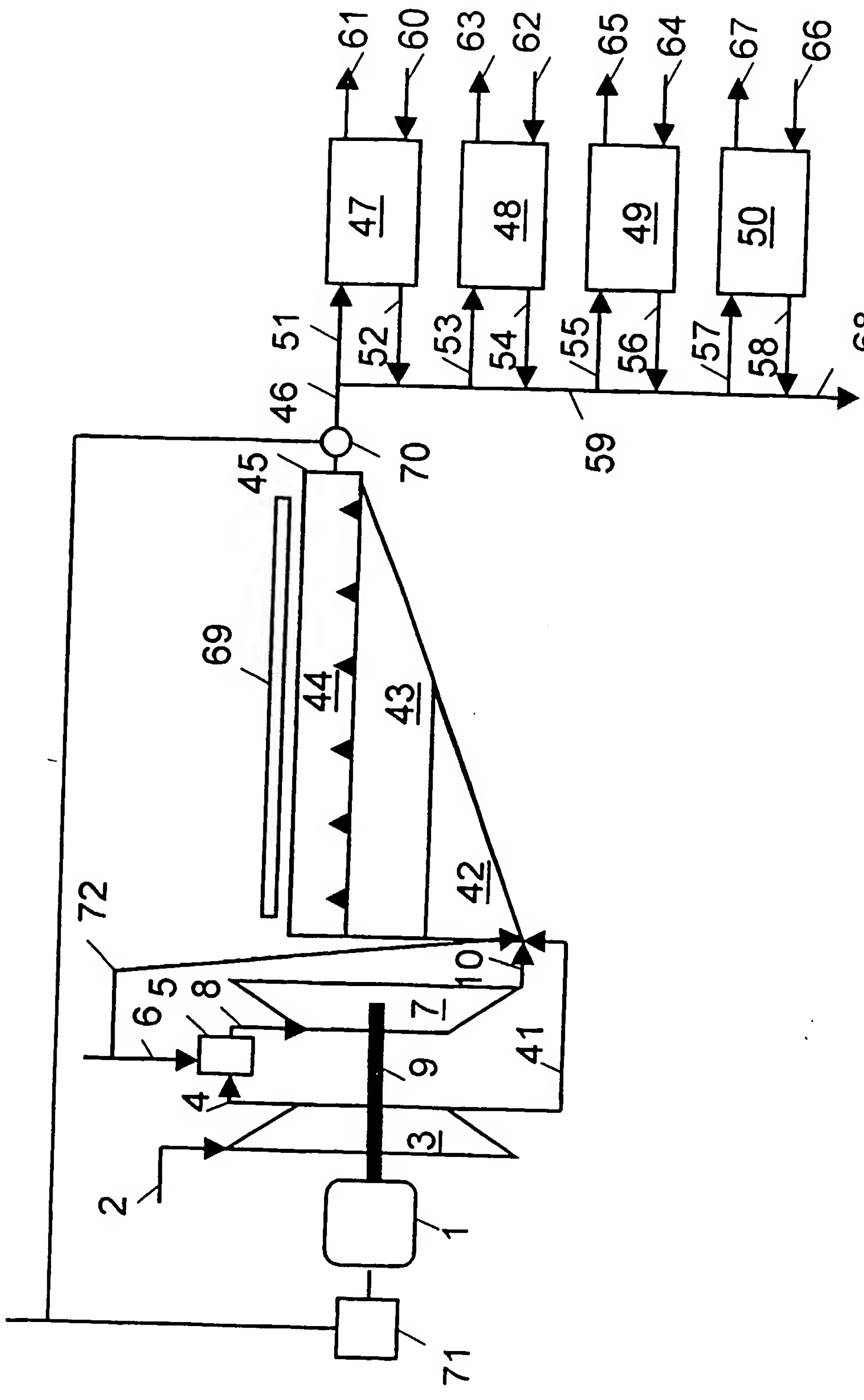
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Fig. 4

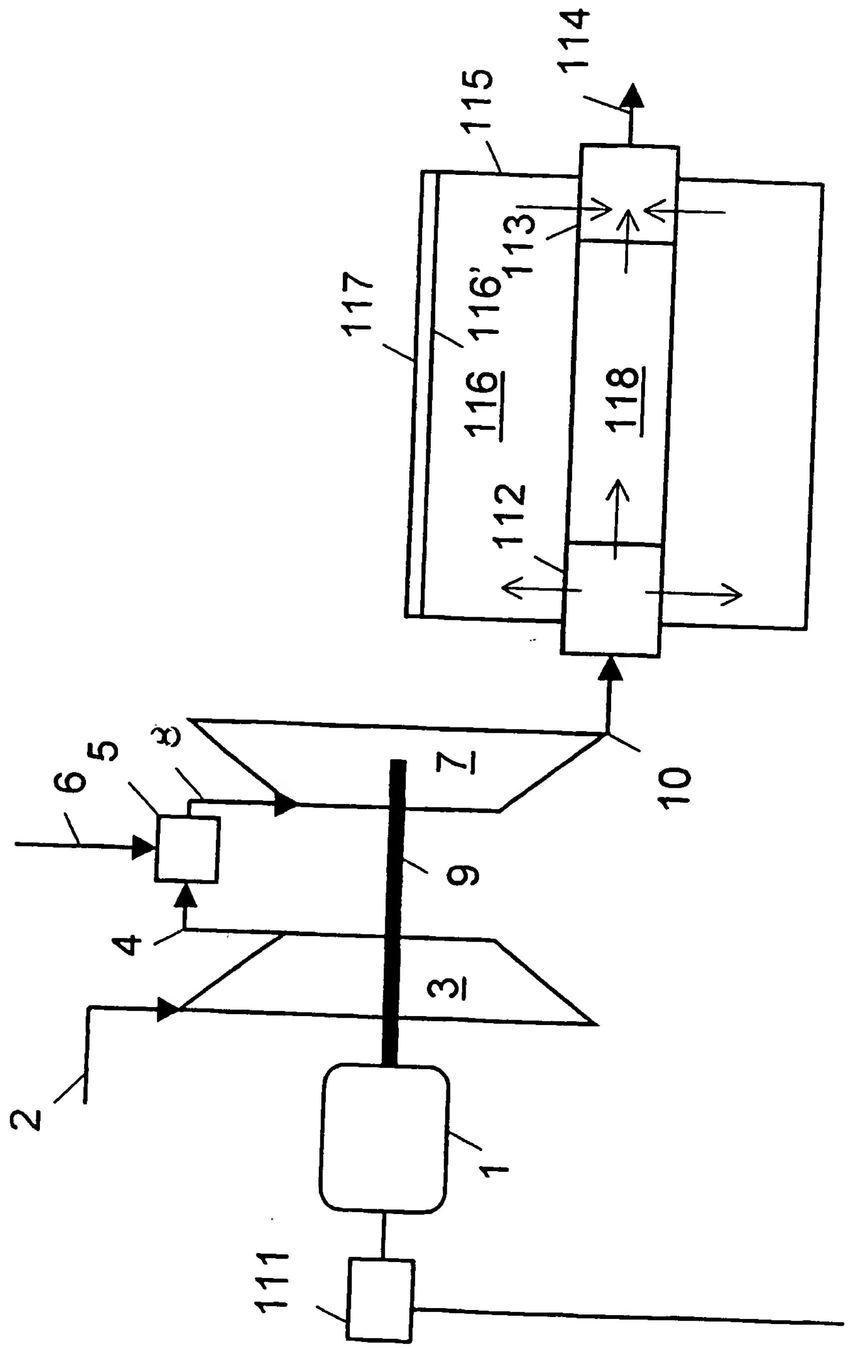

Fig. 5

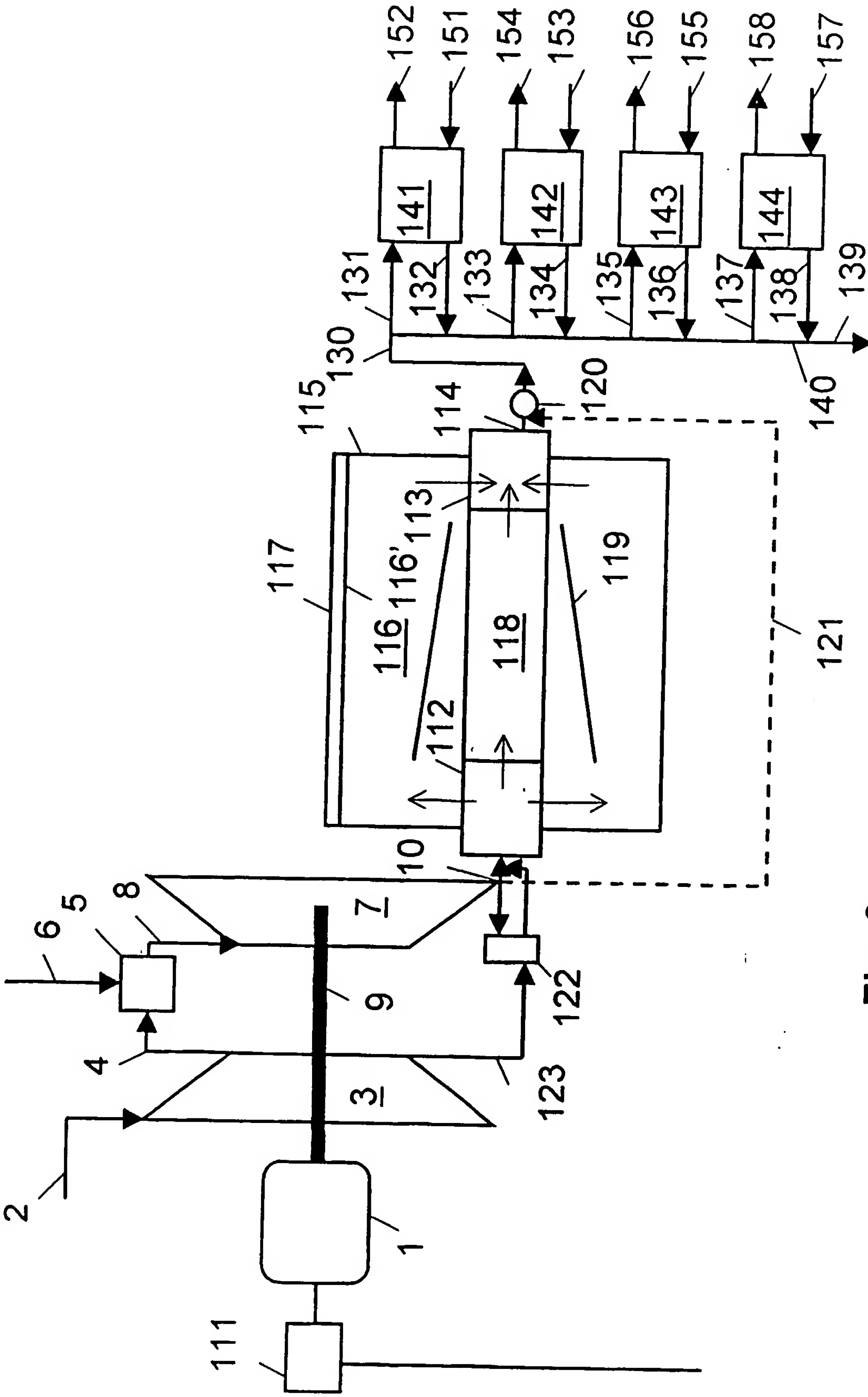
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Fig. 6

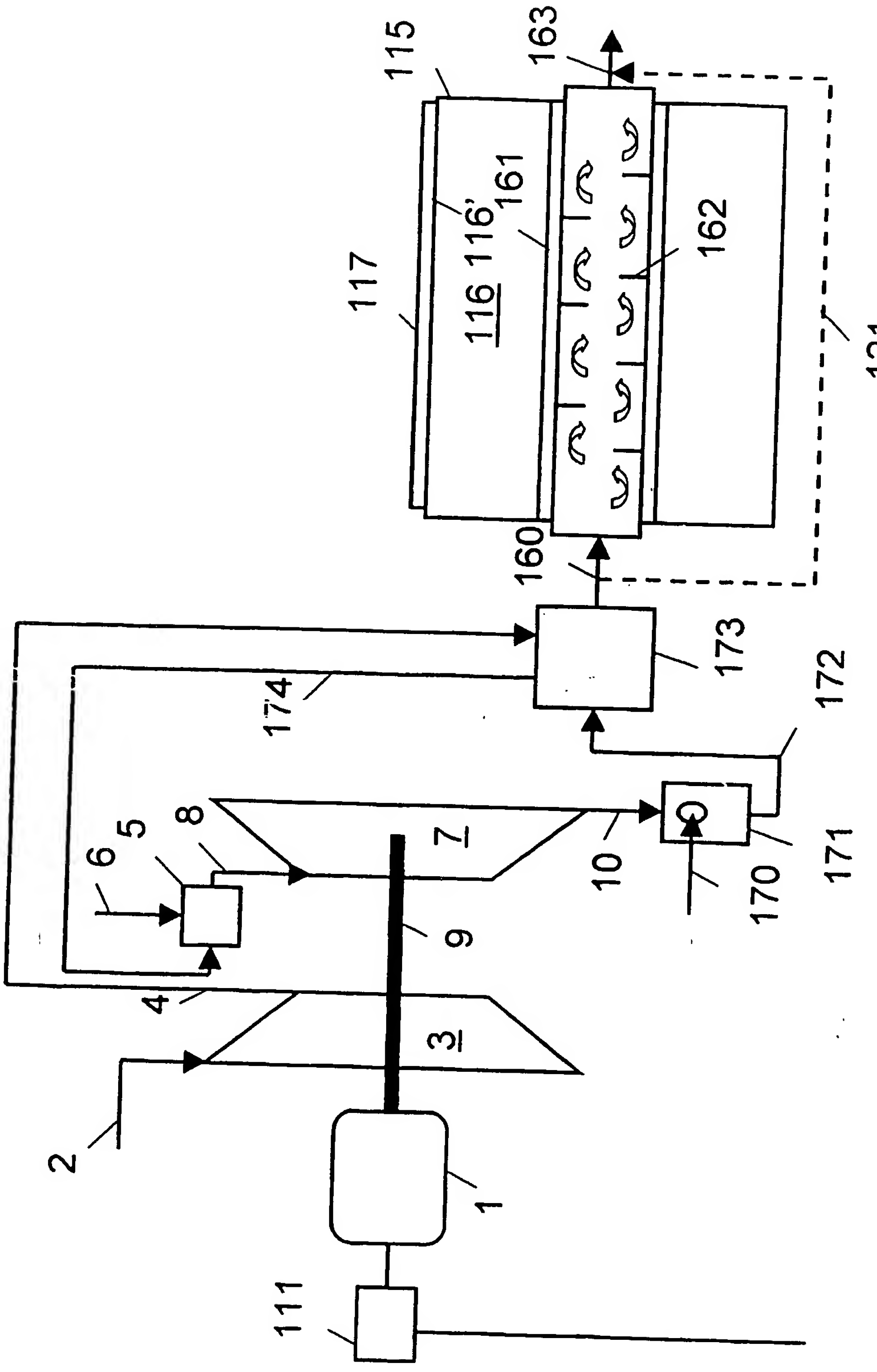
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Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 02/00864

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F02C 6/18, F26B 11/04, F26B 3/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F26B, F02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6173508 B1 (STROHMEYER, JR.), 16 January 2001 (16.01.01) --	1-20
X	US 5653042 A (BESNARD), 5 August 1997 (05.08.97) --	1-20
A	FR 2470941 A (GAME YVAN HENRI), 12 June 1981 (12.06.81) --	1-20
A	SE 465481 B (OLA MILESSON), 16 Sept 1991 (16.09.91) --	1-20

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 February 2003	12 -02- 2003
Name and mailing address of the ISA/ Swedish Patent Office	Authorized officer

International application No.
PCT/FI 02/00864

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 8803605 A1 (A. AHLSTOM CORPORATION), 19 May 1988 (19.05.88)	1-20

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INTERNATIONAL SEARCH REPORT
Information on patent family members

30/12/02

International application No.
PCT/FI 02/00864

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		NO 883018 A	06/07/88
		US 4827711 A	09/05/89